3.0 NUMERIC TARGETS

Numeric targets identify specific endpoints in sediment, water column, or tissue that equate to attainment of water quality standards. Multiple targets may be appropriate where a single indicator is insufficient to protect all beneficial uses and/or attain all applicable water quality objectives. The water quality objectives and beneficial uses for San Diego Creek and Newport Bay are discussed in Section 2 of this document. The range of beneficial uses identified in the Basin Plan for these waters makes clear that the targets must address the protection of aquatic organisms, wildlife (including federally listed threatened and endangered species) and human consumers of recreationally and commercially caught fish.

Where applicable water quality objectives are numeric, TMDL targets are often set to that value. However, where applicable water quality objectives are in narrative form, it is necessary to develop quantitative target(s) through which narrative water quality objectives can be attained. As described below, this document recommends water column targets based on the numeric criteria in the CTR, and sediment and fish tissue targets intended to assure compliance with the Basin Plan narrative objectives for toxic substances (see Section 2).

3.1 Water Column Targets

The California Toxics Rule (CTR), promulgated by USEPA in 2000, contains the only numeric regulatory water quality criteria for the organochlorine pollutants (see Table 2-2). The CTR criteria are intended to protect aquatic organisms, predator species (e.g., the chronic marine water quality criteria for DDT is protective of brown pelican), and humans. However, because the OC pollutants are hydrophobic and have low water solubility, existing data showing detectable concentrations of these contaminants are limited. Furthermore, the detection limits of many of the analytical methods that have been used in monitoring programs currently being implemented in the watershed are often higher than the CTR concentrations for the OC pollutants. Therefore, CTR water column concentrations were not used as primary targets in these TMDLs.

3.2 Sediment Targets

Several approaches to evaluating and selecting the most appropriate sediment targets were considered. Each approach has inherent strengths and weaknesses and these are discussed below.

3.2.1 Selection of sediment targets from literature values that were empirically derived based on statistical evaluation of effects/no effects toxicity data sets.

A number of empirically derived sediment quality guidelines (SQGs) have been identified via statistical evaluation of large, nationwide datasets, and these SQGs predict the probability of adverse aquatic life effects that are associated with different levels of sediment contamination for individual pollutants. Most familiar are the NOAA Screening Quick Reference Tables (SQirRTs) SQGs identified in Buchman (1999). These SQGs provide screening concentrations for freshwater and marine sediments, and are used by NOAA to evaluate potential impacts to coastal resources and habitats from hazardous waste sites. These SQGs are not regulatory criteria and are not endorsed by NOAA as such. However, these SQGs are commonly used by regulatory agencies, research institutions, and environmental organizations to evaluate contaminated sites, characterize sites for disposal of dredged material, and establish goals for cleanup and source control (Vidal and Bay, 2005). Some commonly used SQGs are defined below.

Low-Threshold SQGs. Low-threshold SQGs include Threshold Effects Levels (TELs) for both freshwater and marine sediments, and Effects Range-Low (ERLs) for marine sediments. The ERL is the lower 10th percentile concentration of the available sediment toxicity data that have been screened for samples that were identified as toxic by the original investigators (Buchman, 1999). TELs are the geometric mean of the 15th percentile concentration of the toxic effects data set and the median of the no-effect data set; the TEL represents the concentration below which adverse effects would occur only rarely. TELs and ERLs are, therefore, considered to provide a high level of protection for aquatic organisms (MacDonald et al., 1996).

High-Threshold SQGs. High-threshold SQGs include Effects Range-Median (ERMs) and Apparent Effect Thresholds (AETs) for marine sediments, and Probably Effects Levels (PELs) for both freshwater and marine sediments. The ERM is the median concentration of the compilation of toxic samples in a dataset. The PEL is the geometric mean of the 50th percentile of toxic samples, and the 85th percentile of non-impacted samples; pollutant concentrations above the PEL would be expected to result in toxicity frequently and, therefore, provide a lower level of protection for aquatic organisms. AETs relate contaminant concentrations of synoptic biological indicators of injury, and represent the concentration above which adverse biological impacts would always be expected to occur due to exposure to that pollutant alone.

Consensus-based SQGs have been developed for freshwater sediments (MacDonald et al., 2000), and include Threshold Effects Concentrations (TECs) and Probable Effect Concentrations (PECs). TECs are low-threshold SQGs, and are intended to identify concentrations below which adverse effects are not expected. PECs, on the other hand, are high-threshold SQGs, and represent concentrations above which harmful effects on benthic organisms are expected to occur frequently.

Figure 3-1 shows a conceptual depiction of ranges of biologic effects that can be predicted by low- and high-threshold SQGs (e.g., TELs and PELs, respectively).

SQGs should be used with caution since individual SQGs are often unreliable indicators of toxicity and do not necessarily identify the correct cause of toxicity (Vidal and Bay, 2005). In particular, use of empirically-derived marine SQGs for DDT and PCBs has been found to be relatively inaccurate in predicting toxicity (Long et al., 1995). For this reason, the State Listing Policy states that SQGs are not to be used in isolation to arrive at a finding of impairment, but may only be used when coupled with toxicity or other biologic effects data. The State Listing Policy does not endorse the use of any SQG for DDT in marine sediments for purposes of conducting an impairment assessment.

When a finding of impairment has been made, however, and in the absence of sufficient site-specific information that would allow for selection of appropriate sediment targets using other approaches, designating low-threshold SQGs as quantitative targets may be justified in TMDLs for OC pollutants, for the following reasons:

1) SQGs provide a direct link between pollutant concentrations in sediment and demonstrated biologic effects;
2) While high SQGs may be unreliable predictors of toxicity, low SQGs may be more effective predictors of nontoxicity. Low-threshold SQGs may provide an effective quantitative goal, such that if sediment concentrations are reduced accordingly, then beneficial uses should be protected and adverse biologic effects should be reduced or eliminated.
3) SQGs are derived from datasets where multiple contaminants were likely present in sediments and may have contributed to the observed biologic effects; thus, SQGs are conservative targets for individual pollutants.
4) SQGs are commonly used in the scientific and regulatory communities to evaluate contaminated sites, characterize sites for disposal of dredged material, and establish goals for cleanup and source control. Low-threshold SQGs have been used in other regions in the state as sediment targets in TMDLs for organochlorine compounds.

3.2.2 Back-Calculation of Sediment Targets from CTR using Empirically-Derived Water-Sediment Ratios (WSRs)

This approach is documented in the Ecological Risk Assessment of the Marine Sediments at the United Heckathorn Superfund Site (USEPA, 1994). The sediment concentration necessary to achieve a target water column concentration (CTR) can be predicted from:

$$C_s = C_w \div WSR \quad (1)$$

where, C_s = allowable sediment concentration (μg/kg dw)
C_w = target whole water concentration from CTR (μg/L)
WSR = water-sediment ratio (kg/L) measured at the site

This approach assumes a fairly predictable relationship between pollutant concentrations in water and sediment, but does not assume equilibrium partitioning. Using this approach in the United Heckathorn project, USEPA determined that the range in DDT concentrations in sediments from five different sites should be from 50 to 596 μg/kg dw in order to achieve the CTR human health criterion, and the range was 84 to 1010 μg/kg dw to achieve the CTR chronic water quality criterion. Due to the paucity of site-specific water column chemistry data in the Newport Bay/San Diego Creek watershed, WSR values cannot be calculated and, thus, sediment targets could not be developed using this approach.

3.2.3 Back-Calculation of Sediment Targets from CTR using Equilibrium Partitioning (EqP)

The EqP approach assumes that sediments are in equilibrium with pore water, and that pollutant concentrations in sediments and porewater are related by a partition coefficient (K_{oc}). The relationship is represented as follows:

$$C_s = f_{oc} K_{oc} \times C_w \quad (2)$$

where, C_s = allowable sediment concentration (μg/kg dw)
f_{oc} = fraction of organic carbon in sediment
K_{oc} = organic carbon/water partition coefficient (L/kg)
C_w = target pore water concentration (assumed to be CTR criterion; μg/L)

To calculate the target sediment concentration for total DDT, for example, if the log K_{oc} values identified in Table F-1 of the USEPA technical TMDLs (2002) are used, and log K_{oc} for total DDT is corrected to reflect the relative abundance of each of the DDT species in Newport Bay (corrected log K_{oc} = 6.67), the sediment concentration required to ensure that the CTR marine chronic water quality criterion would be met is 56 μg/kg dw at 1% carbon; the sediment concentration required to meet the human health criterion would be 28 μg/kg dw. Because Newport Bay and San Diego Creek both have REC1 beneficial uses, the human health criterion would be most appropriately used to back-calculate sediment targets, if this approach were to be followed.

While this approach may be desirable because it uses adopted numeric objectives as a reference point, it also has many disadvantages, and these are discussed below.

(1) The EqP approach assumes equilibrium conditions. Equilibrium conditions may never be reached in Newport Bay and San Diego Creek because of tidal circulation in the bay and flows in the creek that create fluctuations in pollutant concentrations in sediment and overlying water.

(2) The approach assumes that aquatic organisms accumulate only pollutants derived from porewater. It does not allow for bioaccumulation from ingestion of sediment or other dietary intake;

(3) From Equation 2, it can be seen that sediment targets calculated using this approach are extremely sensitive to the organic carbon fraction in sediment and the choice of partition coefficient. The percent organic carbon in bay sediments is extremely variable. In Sutula, et al. (2005), percent organic carbon ranged from 3.5% to 12% throughout the study site; in Bay et al. (2004), triplicate same-day sampling at one location in the bay showed organic carbon in sediments ranging from 1.1 to 2.3%. There is also substantial uncertainty related to K_{oc} values. K_{oc} may be derived from the linear relationship between K_{oc} and K_{ow} (Hoke et al., 1994), as was done in the USEPA promulgated TMDLs, and some degree of uncertainty may exist using this derivation. The choice of K_{ow} values for each of the OC pollutants would be made from the range of K_{ow} values that have been reported in scientific literature, none of which are specific to Newport Bay. Further uncertainty would, thus, be introduced in the selection process. Choice of K_{oc} and K_{ow} have a tremendous influence on the calculated sediment target. For example, USEPA chose literature values for log K_{ow} for each of the DDT species: DDT, DDE, and DDD, and assumed that the log K_{oc} for total DDT would be equal to the arithmetic mean of each of the individual species (log K_{oc} = 6.48). Using this value and assuming 1% total organic carbon (TOC), the calculated sediment target to be protective of human health would be 18 μg/kg dw. Using a weighted average log K_{oc} to reflect the relative abundance of each of the DDT species in Newport Bay sediments (log K_{oc}=6.67), the calculated sediment target would be 28 μg/kg dw. Therefore, even a very small difference in log K_{oc} value can translate into a very large difference in the calculated sediment target. USEPA estimates that calculated

sediment targets may vary by a factor of 10-100, depending on assumptions made with respect to TOC and K_{ow} (personal communication, Cindy Lin, USEPA), and this approach may be best suited in instances where substantial site-specific data exist.

Because of the large number of assumptions that are required and amount of uncertainty that is inherent in back-calculating sediment targets, this approach was not followed in arriving at numeric targets.

3.2.3 Calculation of Sediment Targets using BSAFs

The biota-sediment accumulation factor (BSAF) is defined as:

$$BSAF = \frac{C_t}{f_t} \div \frac{C_s}{f_{oc}} \qquad (3)$$

where, C_t = organism tissue concentration (μg/kg ww)
f_t = the lipid fraction in the organism
C_s = pollutant concentration in sediment (μg/kg dw)
f_{oc} = organic carbon fraction of sediment

When a significant relationship has been established between pollutant concentrations in a target organism and in sediment, a "safe" sediment concentration can be calculated by dividing an appropriate tissue endpoint (e.g., NAS guideline) by the BSAF value. This empirical model accounts for pollutant bioavailability, since concentrations are normalized to organic carbon content in sediments and lipid content in tissue.

To measure BSAFs, sediment samples need to be representative of the spatial and temporal history of the organism. That is, sediments should be obtained from the organism's home range during a time the organism would have been exposed to them. This approach is being pursued by San Francisco Estuary Institute, a research group that is performing empirical and mechanistic modeling, using Newport Bay as a case study, in support of development of sediment quality objectives for the State. This work has not yet been completed; however, results of their efforts may enable refinement of sediment targets, ensuring that the most sensitive wildlife receptors in Newport Bay are protected, in future phases of these TMDLs.

3.3 Fish Tissue Targets

3.3.1 Targets for Human Health Protection

There are no regulatory numeric criteria for fish tissue. The California Office of Environmental Health Hazard Assessment (OEHHA) has developed non-regulatory sport fish tissue screening values (SVs) to assess the need for further investigation to determine if a fish advisory may be warranted. These SVs were derived for the 10^{-5} cancer risk, assuming a 70 year consumption duration for adults with a particular body weight and rate of consumption (see Figure 2-3). In these TMDLs, OEHHA SVs were used to assess water quality impairment, and also serve as fish tissue targets for protection of human health. (Note that CTR human health criteria are based on a 10^{-6} cancer risk factor, while OEHHA SVs are based on a 10^{-5} cancer risk.)

Derivation of Fish Tissue Target Values from CTR Water Quality Criteria**.** As an alternative to using OEHHA SVs, fish tissue endpoints could be back-calculated from CTR human health criteria using bioconcentration factors obtained from the scientific literature, assuming the following relationship:

$$TTRL = C_w \times BCF \quad (4)$$

where, TTRL = Threshold Tissue Residue Level (μg/kg ww)
C_w = CTR Human Health Water Criterion (μg/L)
BCF = Applicable bioconcentration factors derived from the literature (L/kg)

As an example for DDT, using the BCF published in the USEPA 1980 Ambient Water Quality Criteria for DDT of 53,600, the allowable TTRL in muscle fillet would be 32 μg/kg wet weight, which is less than the OEHHA SV of 100 μg/kg ww. The calculated TTRL for protection of human health would also be protective of aquatic life, since the CTR value for protection of human health is much lower than the acute or chronic criterion for protection of aquatic life.

Derivation of BCF values is performed through controlled laboratory experiments; calculated values differ among laboratories, and therefore selection of any one particular BCF value could be subject to controversy. BCF values are used when the only source of uptake by an organism is via water. If uptake occurs via multiple pathways (e.g., diet), as could reasonably be expected to occur in benthic organisms or bottom-feeding fish in Newport Bay, then TTRLs calculated using BCFs may not be accurate. For these reasons, this approach was not used for arriving at fish tissue target values for these TMDLs.

3.3.2 Targets for Protection of Aquatic Life and Wildlife

The NAS guidelines provide non-regulatory criteria for whole fish tissue that are intended to be protective of freshwater aquatic life and predator species, as well as marine aquatic life and fish-eating birds. While these guidelines are dated (1972), they are endorsed by the state for use in assessing impairment related to bioaccumulative pollutants. These guidelines were used as fish tissue targets in development of these TMDLs to ensure that aquatic life and higher trophic level wildlife beneficial uses are adequately protected.

3.4 Conclusions

Sediment targets were prioritized over water column and fish tissue targets, based on the following rationale:

(1) The OC pollutants are directly associated with fine sediment;
(2) The OC pollutants are primarily transported within the watershed via sediment transport;
(3) Limited water column data are currently available;
(4) Impacts to the biota occur through bioaccumulation and biomagnification of the OC pollutants, and these impacts can ultimately be related to concentrations in sediment; and
(5) Attainment of sediment targets should result in attainment of water column criteria and tissue screening values, and thus should offer protection of aquatic life, wildlife, and human health.

Low SQGs (TELs) were chosen as quantitative sediment targets over other methods of deriving sediment targets because:

(1) They directly link sediment concentrations to biologic effects;
(2) They do not have the degree of uncertainty related to TOC and K_{oc}/K_{ow} as in the back-calculation approach;
(3) They do not require substantial site-specific information as in other approaches;
(4) They are conservative values, in that they were derived from datasets with multiple sediment contaminants;
(5) There is precedence for their use in development of OCs TMDLs in southern California;
(6) Their strengths and limitations are well-understood.

The sediment, water column, and fish tissue targets for the OCs TMDLs are provided in Table 3-1. These targets are identical to those selected by USEPA in development of the technical TMDLs (2002); however fish tissue targets for protection of aquatic life and wildlife have also been added.

The linkage between adverse effects in sensitive wildlife species and concentrations of the organochlorine pollutants in sediments, prey organisms and water is not well understood at the present time, although work is underway to better understand ecological risk in Newport Bay, and the state is in the process of developing policy for determining site-specific sediment quality objectives. Reducing contaminant loads in the sediment will result in progress toward reducing risk to aquatic life and wildlife. During implementation of these TMDLs, additional wildlife targets will be identified as risk assessment information becomes available.

Table 3-1. Numeric Sediment, Fish Tissue, and Water Column TMDL Targets

Sediment Targets[1]; units are μg/kg dry weight				
	Total DDT	**Chlordane**	**Total PCBs**	**Toxaphene**
San Diego Creek and tributaries	6.98	4.5	4.1	0.1
Upper & Lower Newport Bay	3.89	2.26	21.5	
Fish Tissue Targets for Protection of Human Health[2]; units are μg/kg wet weight				
San Diego Creek and tributaries	100	30	20	30
Upper & Lower Newport Bay	100	30	20	
Fish Tissue Targets for Protection of Aquatic Life and Wildlife[3]; units are μg/kg wet weight				
San Diego Creek and tributaries	1000	100	500	100
Upper & Lower Newport Bay	50	50	500	
Water Column Targets for Protection of Aquatic Life, Wildlife & Human Health[4] (μg/L)				
San Diego Creek and tributaries				
Acute Criterion (CMC)	1.1	2.4		0.73
Chronic Criterion (CCC)	0.001	0.0043	0.014	0.0002
Human Health Criterion	0.00059	0.00059	0.00017	0.00075
Upper & Lower Newport Bay				
Acute Criterion (CMC)	0.13	0.09		
Chronic Criterion (CCC)	0.001	0.004	0.03	
Human Health Criterion	0.0059	0.00059	0.00017	

[1]Freshwater and marine sediment targets are TELs from Buchman, M.F. 1999. NOAA Screening Quick Reference Tables, NOAA HAZMAT Report 99-1, Seattle WA, Coastal Protection and Restoration Division, National Oceanic and Atmospheric Administration, 12 pp.

[2]Freshwater and marine fish tissue targets for protection of human health are OEHHA SVs

[3]Freshwater and marine fish tissue targets for protection of aquatic life and wildlife are from Water Quality Criteria 1972. A report of the Committee on Water Quality Criteria, Environmental Studies Board, National Academy of Sciences, National Academy of Engineering. Washington, D.C., 1972.

[4]Freshwater and marine targets are from California Toxics Rule (2000).

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